Table 4: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	0.89 (0.71-1.11)	740
Total Leukaemia	1.24 (1.09-1.40)	1206
Lymphatic Leukaemia	1.32 (1.09-1.59)	536
Myeloid Leukaemia	1.09 (0.91-1.32)	563
Other Leukaemia	1.67 (1.12-2.49)	107
Mortality		
Brain Tumour	0.82 (0.63-1.07)	606
Total Leukaemia	1.17 (0.96-1.43)	847
Lymphatic Leukaemia	1.39 (1.00-1.92)	267
Myeloid Leukaemia	1.01 (0.82-1.24)	493
Other Leukaemia	1.57 (1.01-2.46)	87

Table 5: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in childhood (0-14 years) in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	1.01 (0.59-2.06)	64
Total Leukaemia	1.58 (1.07-1.34)	134
Lymphatic Leukaemia	1.55 (1.00-2.41)	107
Myeloid Leukaemia	1.73 (0.62-14.81)	9
Other Leukaemia	1.65 (0.33-8.19)	8
Mortality		
Brain Tumour	0.73 (0.26-2.10)	30
Total Leukaemia	2.32 (1.35-4.01)	59
Lymphatic Leukaemia	2.74 (1.42-5.27)	39
Myeloid Leukaemia	1.77 (0.47-6.69)	11
Other Leukaemia	1.45 (0.30-6.99)	9

12.1.3 Exposures:

Exposure levels were calculated for the 4 individual TV stations. They were combined and plotted against the geographic centre of the three TV towers, Figure 23. The frequencies involved are in the range 63 - 219 MHz and 626-633 MHz.

Within a radius of about 1 km or so the area is inside the circle of the towers themselves. The high readings between 4 to 8 μW/cm^2 at about 1 km are the areas immediately adjacent to each of the towers where few, if any, people reside. At the geographic centre, between the towers, the calculated exposures are in the range 1 to 2μW/cm^2. Outside the circle of the towers themselves their combined calculated level of exposure falls from about 1μW/cm^2 at 2 km from the centre, to 0.2μW/cm^2 at 4 km and 0.08μW/cm^2 at 8km. Thus the exposed population resides in calculated outdoor levels between 0.2 and 1μW/cm^2. Measurements found that in the region of Tower 1 the actual levels, among the rolling terrain, trees and buildings, were 5 times lower than those calculated. Indoor exposures would be 4 to 8 times lower again. Hence mean residential exposure for the inner group is in the range 0.01 to 0.2μW/cm^2, or less.

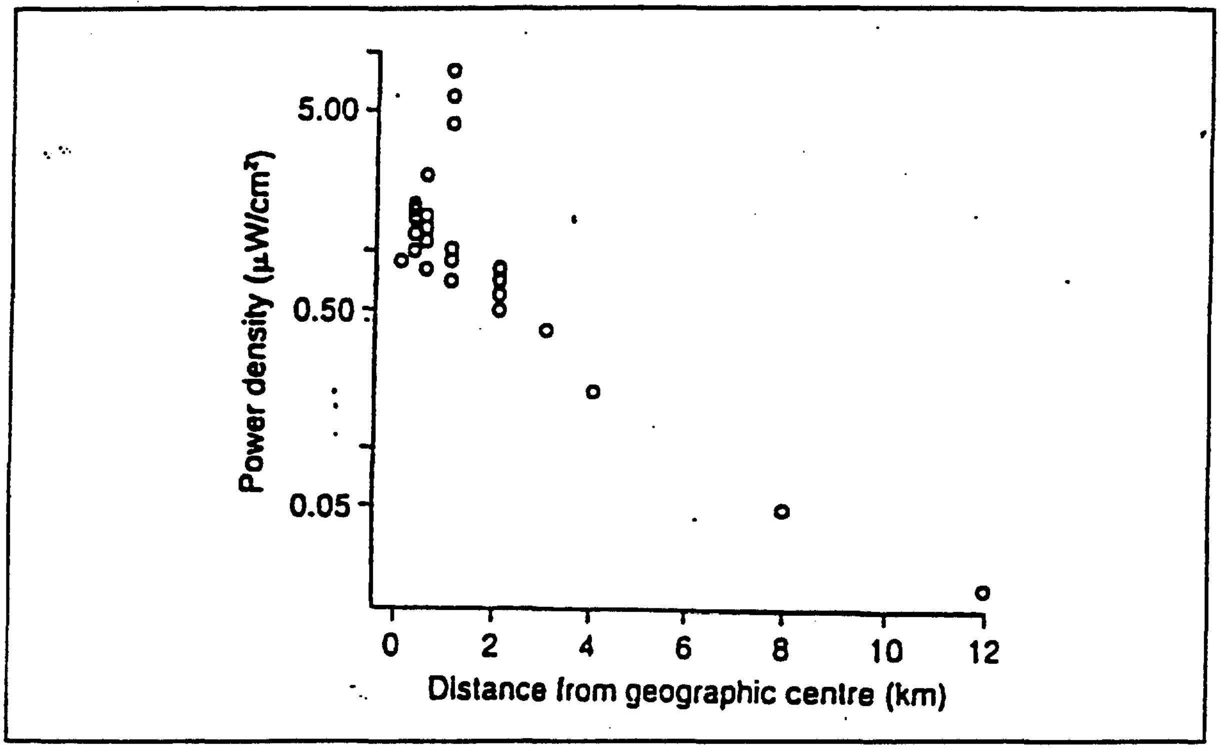

Figure 23: Logarithm of the calculated power densities (in μW/cm^2) for TV signals from the three TV towers against distance from the centre of the towers.

12.1.4 Dealing with confounders:

Hocking et. al (1996) searched diligently to find confounders to explain these results. They investigated and found no bias due to socio-economic class, proximity to industry, density of traffic (and hence benzene levels), air pollution, ionising radiation, high voltage power lines, population movement, nor the location of hospitals.

12.1.5 Conclusions:

This is a highly significant study, carried out very carefully, with no pre-determined view of a positive association being expected. The study was originally sponsored by Telstra (formerly Telecom Australia) as a "toe in the water study" to ally fears about health effects of cell sites according to Dr Bruce Hocking on National Radio with Kim Hill. The results prove the opposite conclusions that there is a probable but not proven effect from RF exposure from cell sites of increased risk of childhood leukaemia and lower, but still statistically significant increased risk of adult leukaemia.

Consistency with other, less detailed and less comprehensive studies, which have also found positive associations with cancer, including leukaemia and brain tumour in association with elevated RF/MW radiation exposure, provides compelling evidence of increased risk of cancer, especially leukaemia in children, from chronic low level RF exposure at the level of a probable to highly probable human carcinogen.

The Planning Tribunal was also not told of the desire of a research team contracted to the U.S.E.P.A. to have RF/MW radiation classified as a possible human carcinogen in 1990. With the Hocking and other more recent studies E.P.A. officials agree that the evidence in now even stronger. See Section 13.3 below.

12.2 The Skrunda Radar Study:

12.2.1 Introduction:

A radar location station in Latvia, near the town of Skrunda, has been operating for over 20 years. People live on the land in front of the radar, with villages, farms and forestry being the predominant features.

12.2.2 Associated Human Effects:

Although the local population have recorded many health complaints, the health effects have not been reported yet. A study has been carried out on children's performance, comparing the children in a village up to 20 km from Skrunda but in front of the radar, with children who live behind the radar.

Kolodynski and Kolodynski (1996) studied a group of 966 children (425 males and 541 females) aged 9-18 years. A total of 609 children were examined from the Kuldiga and Saldus regions within a 20 km radius of the Skrunda RLS. Of these, 224 pupils live in directly exposed areas to the west of the radar. The control group were 357 pupils from the Preili region, behind the radar.

For the populations living in front of the radar and behind it, and for the control group, groups of similar age and sex were selected. They examined similar social groups of farming communities, and 95 % of subjects lived on small farms.

They conclude that "the weak correlations between the distance from the children's homes to the RLS, and the children's responses, are certainly consistent with the idea of an electromagnetic field effect."

Statistically significant differences were observed between the performance of exposed and control groups of children which leads to the conclusion:

> **"The children living in front of the Skrunda RLS have less developed memory and attention, slower reaction times and decreased endurance of neuromuscular apparatus. On the basis of the data obtained, one could**

propose the working hypothesis that the decreased endurance of muscular apparatus, slower reaction time and less developed memory and attention are the results of chronic electromagnetic radiation effects. Evidence for a factor other than electromagnetic field having caused the observed results was not found, but its existence cannot be ruled out, for example, differences in the past experiences of the children, local small pollution effects, differences in family behaviour, etc."

While confounding effects cannot be ruled out, the evidence for the changes in children's performance is most plausibly related to the very low emissions of pulsed RF radiation from the Skrunda radar. Whether it is the RF energy or the pulse rate or size is not known. The pulse rate is unlikely to have had the operative effect on plants, people and animals. The "working hypothesis" proposed constitutes evidence of a potential adverse environmental effect.

12.2.3 Human Exposures:

Exposures were measured with frequency sensitive equipment, Kalnins et al. (1996), and so the measured readings relate to the output of the radar as against the broad band ambient radiofrequency exposure from all emissions which is likely to be around 0.001μW/cm^2. Hence measurements or estimates of radar signals below this level will be irrelevant, unless the effects are frequency specific. Any levels above 0.001μW/cm^2 are localized exposures above the ambient whose effects can potentially be associated with the radar irrespective of whether or not the effects are frequency sensitive.

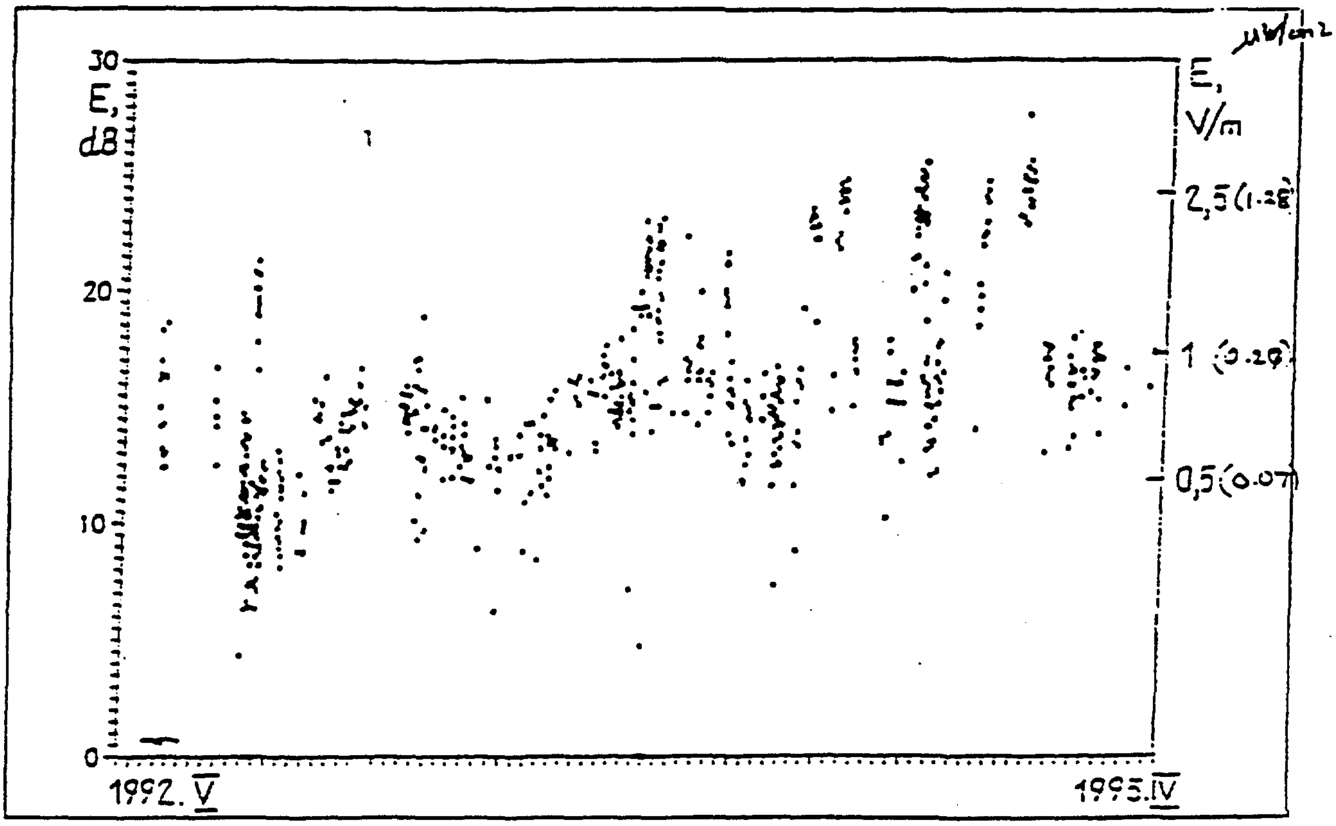

Figure 24: Maximum RMS electric field intensities (E) of electromagnetic radiation at 2 km from the Skrunda RLS between May 1992 and April 1993 at a height of 1.5 m above ground level (AGL).

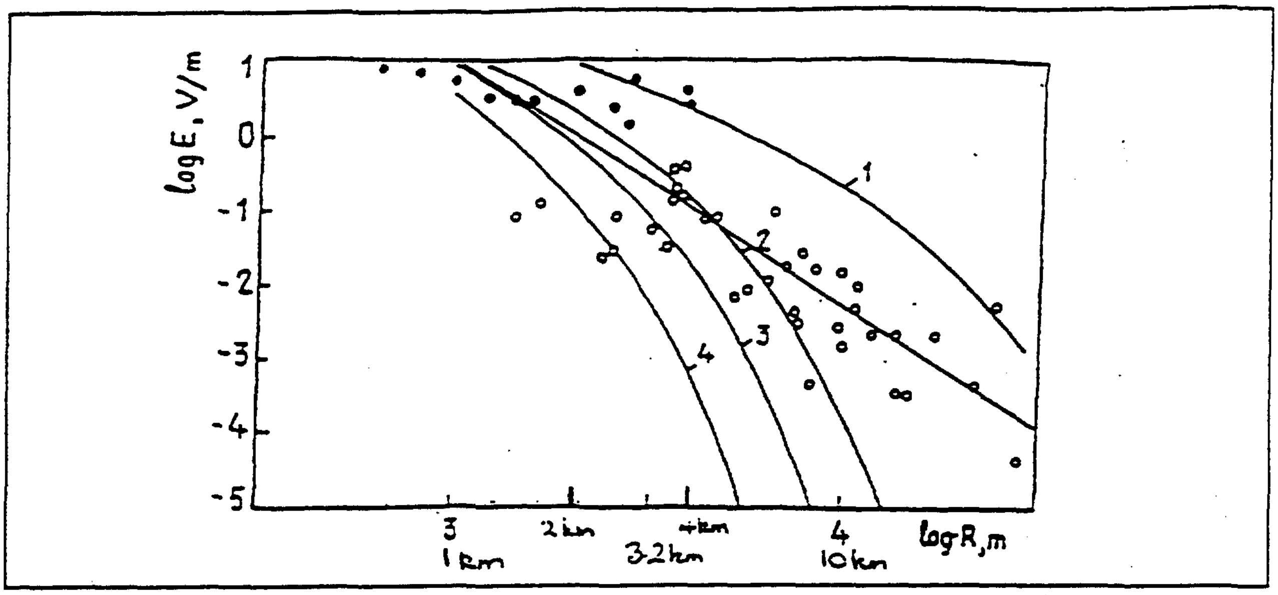

Figure 25: Measured maximum RMS electric field intensity (E) at 2 m AGL, plotted against distance from the Skrunda RLS. Theoretical curves (1-4) for different forest cover, 1 being the least and 4 being the most. A linear fit has been superimposed to estimate mean actual measurements with distance from the 2 km site.

Children living in the exposed zone have been tested for a range of performance parameters. The children lived and went to school in a zone about 4 to 15 km from the radar, with open exposure measurements in the range 0.0008-0.41 $\mu W/cm^2$, mean in the 0.0028- 0.039$\mu W/cm^2$. The measurements range is far wider than the mean range because of short-term variations in the output of the radar and weather conditions, etc. The local measurements (for the radar signal) among the trees and buildings, are in the range 1.7x 10^{-6} - 0.0027 $\mu W/cm^2$. The frequency was in the range 156-162 MHz and the radar is pulsed at a rate of 24.4 Hz and pulse width of 8 ms.

12.2.4 Bovine Effects:

A herd of female Latvian Brown Cows were studied, Balode (1996), using cytogenetical evaluate of chromosome breakage in blood, using a micronuclei method. Comparing a herd of the same type of cows from in front of the radar with a herd housed behind the radar, they found a small incidence of broken chromosomes in the peripheral erythrocytes of the exposed cows of 0.6 per 1000. However this was six times that of the unexposed cows, which is significant at the $p<0.01$ level.

12.2.5 Bovine exposures:

Assuming the herd was within 1 to 2 km of the front of the radar, in open grassy pastures, the measured exposure would be in the range 0.042 to 6.6$\mu W/cm^2$, mean exposures in the range 0.157 to 0.63$\mu W/cm^2$.

12.2.6 Pine tree growth increments:

Many stands of pine trees were studied and reduction in growth ring increment was found. A particular set of stands lie at a radius of about 4 km from the radar, Balodis et al. (1996). Figure 26 shows the growth response of a set of stands of pine trees at a 4 km distance from the radar, where measured exposure levels are in the order of 0.0027μW/cm^2.

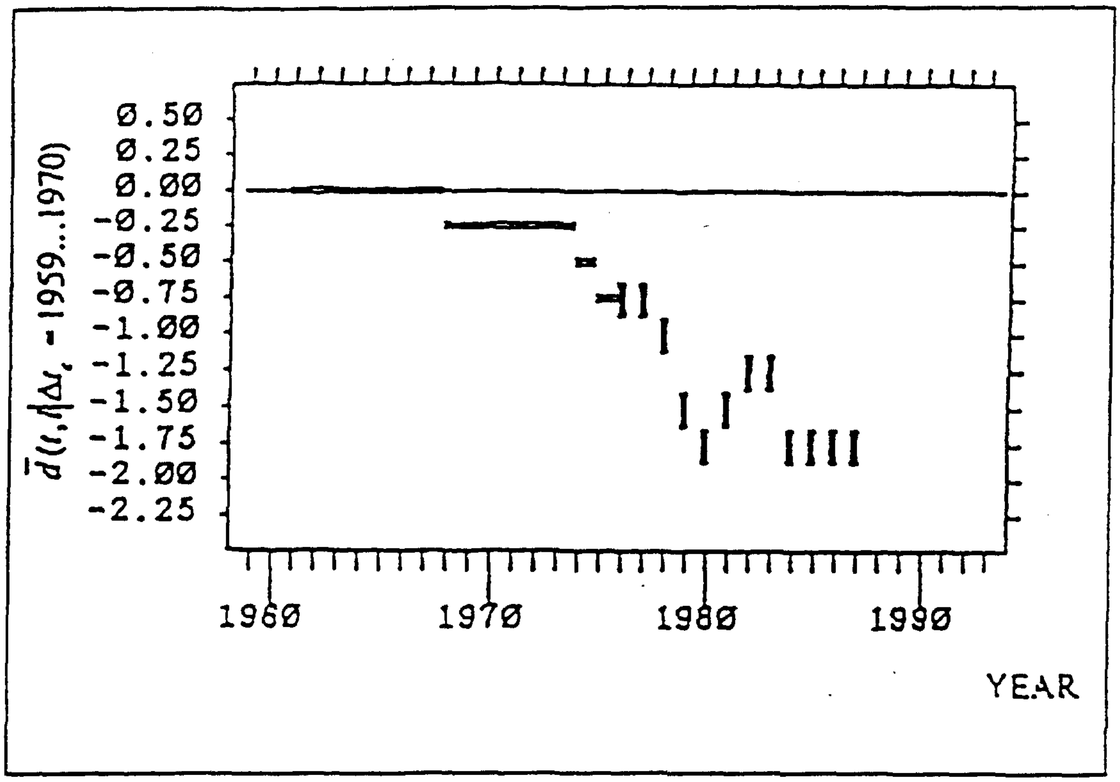

Figure 26: The mean relative additional increment of pine trees for a plot 4 km distance in from of the Skrunda RLS radar. The solid bars depict significant deviations from normal growth.

They conclude,

> **"There is a statistically significant (P<0.01) negative correlation between the relative additional increment in tree growth and the intensity of the electric field. The radial growth of pine trees is diminished in all plots that received electromagnetic radiation. This decrease in growth began after 1970, which coincided with the start of the operation of the Skrunda RLS, and was subsequently observed throughout the period of the study."**

The study team investigated other environmental and anthropogenic factors but found no significant effects to relate to tree growth.

Selga and Selga (1996) investigated the effect of RF exposure on the needles of *Pinus sylvestris L.* They found physiological changes with exposed trees which they state would explain the difference detected in tree ring width. They conclude:

> **"Evidently, EMF induces modification of the Golgi apparatus and switches its functions from synthesis of predecessors of cell walls (lignins) to**

> **formation and export of resin predecessors. The stress due to the RF EMF generated by the Skrunda RLS causes an unspecific response - accelerated resin production and promoted senescence (aging) of pine trees." ... "Phenol-induced senescence of pine trees can explain the decrease in tree ring increment width and viability of pine forests caused by direct pulsed RF EMF irradiation."**

Hence there is strong evidence from plant physiology that gives a biological mechanism to explain the observed decrease in growth rate of pine tree which are exposed to pulsed RF radiation.

12.2.7 Plant reproductive damage:

Magone (1996) investigated the vegetative growth and morphology of the duckweed *Spirodela polyrhiza (L.) Schleiden* . These plants have high vegetative reproduction rates, and genetically uniform clones can be used for experimentation. The results of exposure to the Skrunda RLS irradiation was dramatic.

> **"At 55 days, various morphological and developmental abnormalities appeared in 60 to 100 % of the exposed plants and 1 % of the control plants. Plants developed completely from daughter fronds under exposure from the electromagnetic field had a shorter life-span (67 days compared to 87 days in the controls) and fewer subsequent daughters (8 compared to 10 in the control group)."**

It is also noted that the decrease in reproduction rates and the occurrence of deformities in future generations after 30 days of exposure to pulse-type RF irradiation comes from small cellular changes that become evident only after replication in cell division. This was also supported by the fact that in the experiment to determine life-span, where only the daughters directly produced from the mother were observed, the number of deformities was almost two times lower than when all descendants were observed.

They conclude:

> **"Our work suggests that studies of non-thermal radiofrequency electromagnetic fields on organisms must be comparable to the life-span of the organism. If short-term observations are made, only the organism response to electromagnetic radiation as a stress factor can be seen. Long-term studies can yield different conclusions due to more effects becoming evident only at later times."**

These results are consistent with observed chromosome damage in plants exposed to RF radiation, Haider et al. (1994), who used 10 to 27 MHz broadcast antennae with very high, but sub-thermal exposures of at least $424\mu W/cm^2$ (40 V/m).

12.2.8 Plant exposure levels:

The Pine trees at 4 km were exposed to a range of 0.011 to $0.41\mu W/cm^2$, a mean open field exposure of $0.039\mu W/cm^2$ and measured distance exposure of $0.0027\mu W/cm^2$ (for the radar signal). Indications are that the duckweed study was done closer to the radar and so the bovine exposure levels would be likely to apply, i.e. range 0.042 to 6.6$\mu W/cm^2$, mean exposures in the range 0.157 to 0.63$\mu W/cm^2$.

12.2.9 Summary and conclusions:

The Skrunda Radar provides a living laboratory for the chronic low level effects of exposure to RF/MW radiation. To date investigations have revealed a number of statistically significant changes associated with exposure to the radar signal. These include:

- Impaired scholastic performance of children in the open field exposure range of 0.0008-0.41 $\mu W/cm^2$, mean measured level in the range 0.0028- 0.039$\mu W/cm^2$.

- A 6-fold increase in broken chromosomes in the peripheral erythrocytes of the exposed cows ($p<0.01$). for a measured exposure would be in the range 0.042 to 6.6$\mu W/cm^2$, mean exposures in the range 0.157 to 0.63$\mu W/cm^2$.

- A statistically significant ($P<0.01$) negative correlation between the relative additional increment in tree growth and the intensity of the electric field. The Pine trees at 4 km were exposed to a range of 0.011 to 0.41$\mu W/cm^2$, a mean open field exposure of 0.039$\mu W/cm^2$ and measured distance exposure of 0.0027$\mu W/cm^2$ (for the radar signal). A probable biological mechanism was identified through observed changes in physiological conditions.

- Chromosome and reproductive damage in plants exposed RF/MW in the range 0.042 to 6.6$\mu W/cm^2$.

Chronic exposure to pulsed RF radar signals is associated with chromosome damage in plants and animals, with associated reproductive aberration in plants, and growth reduction in pine trees linked to observed physiological changes, and scholastic impairment of school children occurs in relation to exposure levels which fall well below 2$\mu W/cm^2$, below 0.1$\mu W/cm^2$. and even below 0.01$\mu W/cm^2$.

12.3 The Schwarzenburg Study

12.3.1 Introduction:

Following many years of reported health complains from the vicinity of a shortwave transmission mast, a study by Altpeter et al. (1995) was carried out and revealed statistically significant health and well-being effects which varied systematically with exposure zone. Follow up studies gave strong evidence of the involvement of melatonin as a biological mechanism in relation to sleep disturbance and the reported group of symptoms referred to a "Chronic Fatigue Syndrome".

12.3.2 Exposure levels associated with the radio tower:

Daily average exposures in the frequency range 3 to 30 MHz for each zone are given in Table 6.

The background exposure level in the frequency range 3 to 30 MHz, was measured during a 3-day period when the transmitter was turned off. Levels averaged 0.083 mA/m (0.00183μW/cm^2), with a nocturnal peak of 0.169 mA/m (0.0076μW/cm^2) and an afternoon minimum at about 1pm to 2pm of 0.041mA/m (0.00045μW/cm^2). This diurnal variation is likely to be related to changes in atmospheric conditions such as those which give better shortwave reception at night than during the day.

Table 6 : Daily average exposure levels for each exposure zone from the Schwarzenburg Study (3 to 30 MHz).

Exposure Zone	Exposure Range	Median	Mean (μW/cm^2)
Zone A : High	0.031 - 9.1	0.10	0.24
Zone B: Medium	0.0034 - 0.074	0.024	0.024
Zone C: Low	0.00046- 0.0074	0.0004	0.0004

Globally this relates to the height of the reflecting electron concentration in the ionosphere, which is higher at night and lower during the day. Locally it relates to atmospheric stratification and ducting of high frequency RF signals, such as radios and radars, as has been observed in Canterbury during nor'westers. This suggests the probability of nocturnal ducting of the radio signals from the tower, increasing the nocturnal strength in Zones A, B, and C, and hence making them all prone to sleep disturbance effects (if such is the result of RF exposure as is strongly suggested by Table 4).

Zone C has readings in the range of frequencies produced by the tower from above and below the mean background level. The higher than background levels are likely to be more prevalent at nighttime due to ducting phenomena except during Föhn conditions.

12.3.3 Effects associated with the RF Exposure:

The statistically elevated symptoms in the high and medium exposure groups, compared to the low exposure group, include Nervosity and restlessness, Disturbances in falling asleep and difficulty in maintaining sleep, Joint pains, Psychovegetative Index changes, Disturbances of Concentration, General Weakness and Tiredness, Constipation, Diarrhea and Lower back pain, all significant at $p<0.02$ except the first for which $p=0.034$ which is less than the usual significance level of $p<0.05$.

The insomnia is related to a disturbance of nocturnal melatonin and leads to a general debilitation and lack of mental alertness. This is therefore a very important symptom which warranted extra study. Follow up studies of people's melatonin detected no significant change. However readings were taken after people awoke in the morning and so they did not and would peak which is reached about 2 hours after falling asleep. This problem, and several others, is acknowledged by the authors.

Mean measurements of bovine salival melatonin showed that exposed cows had lower mean melatonin, 17.7 pg/ml compared to 19.0 pg/ml, but this was not statistically significant. It must again be pointed out that it is not the mean melatonin levels which relates to sleep but it is the nocturnal melatonin peak.

An increased exposure from 1 mA/m to 10 mA/m (0.038$\mu W/cm^2$ to 3.8$\mu W/cm^2$) had on Odds Ratio for insomnia of 1.13 (CI: 1.04-1.23) and from 0.1 mA/m to 1 mA/m (0.00038$\mu W/cm^2$ to 0.038$\mu W/cm^2$), OR=2.1 (CI: 0.95-4.57).

12.3.4 Unexpected and unaware transmitter breakdown:

A fortuitous event is very revealing. For three days during the study, the transmitter broke down and emissions ceased, and the people did not know about it. During these three days reported sleep quality was markedly improved from the first night in the high exposure group and from the second night in the middle and low exposure group. Averaging over 3 day intervals for each zone, for before, during and after, starting on day 1 for Zone A and day 2 for Zones B and C, gives the following percentage awakenings:

Table 7: Sleep disturbance rates for 3-day periods before, during and after the transmitter going off.

Exposure	Before	During	After
Zone A (High)	78	62	63
Zone B (Middle)	68	52	63
Zone C (Low)	61	37	54

"Before" shows the level of awakenings increasing with exposure, "After" shows a rate of recovery which is smallest in the high exposure group and highest in the Low exposure group and "During" shows a significant reduction in awakenings which is greatest and most significant in the Low exposure group. It appears that the High exposure group takes many days to recover and so their reaction time, in the order of several days, might limit the level of relief shown by a three day shut down. The Low exposure group get the greatest relief and the fastest reactions. This strongly suggests that even in Zone C the effects of the transmissions on sleep quality is significant. Hence the Odds Ratios of exposed to unexposed are significantly under estimated.

12.3.5 Nocturnal Melatonin and Sleep:

The Bovine melatonin study shows that when the transmission was off the cows in the exposed group had strong nocturnal peaks not seen as pronounced and high at any time when the transmission was on.

These combined observations point strongly to the effect of the RF EMR in decreasing the nocturnal peak of melatonin with an accompanying significant degradation in the quality and maintenance of sleep.

There appears to be little reason to assume that human nocturnal peak melatonin levels were not affected in the same way that the bovine melatonin levels were. Sleep quality, bovine exposed melatonin levels were reduced, bovine nocturnal peak melatonin levels improved when the transmitter was off, sleep improved when the transmitter was off. Hence human nocturnal melatonin reduction this is a reasonable and likely mechanism to explain the reported sleep disturbance and the Chronic Fatigue Syndrome condition, as projected by Reiter (1994), Section 3.1.

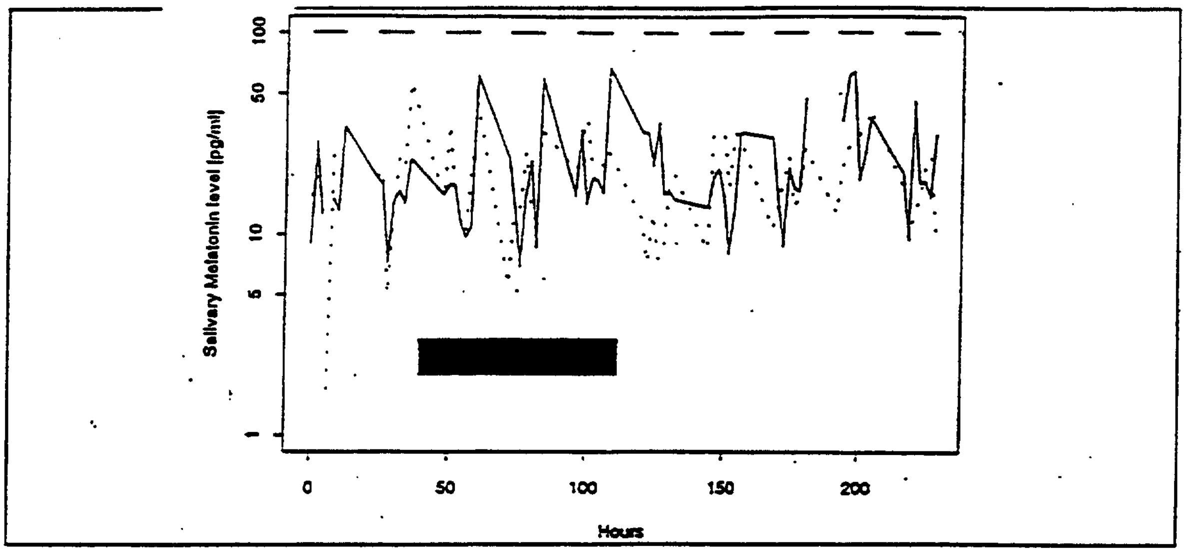

Figure 27: Melatonin concentration measured in the saliva of EMF-exposed (continuous line) and unexposed (dashed line) cows: acute effect of EMF exposure. The lines at 100 pg/ml indicate the dark phases when melatonin concentration was measured, black box is the period of no EMF exposure of both groups. (Altpeter et al. (1995))

Reduced nocturnal melatonin also has significant health implications relating to cancers, such as breast cancer, which has been related to melatonin reduction in laboratory studies, Liburdy et al. (1993) and related to ELF exposure in epidemiological studies, Demers et al (1991) and Section 3.1. This study implicates RF exposure.

12.3.6 Heart and Blood Pressure:

Concerns about heart problems were investigated with a blood pressure and hypertension survey. Normal blood pressure was reported in 55 % in Zone A, 56 % in Zone B and 74 % in Zone C. Arterial hypertension was reported in 14 % in Zone A, 8.4 % in Zone B and 7.9 % in Zone C. An extensive review of reporting and measurements revealed that there was an Odds ratio of 1.4 (CI: 0.75-2.52) for blood pressure difference in Zone A compared with Zones B and C combined. Hence blood pressure was slightly elevated with exposure to EMR, but not significantly so.

12.3.7 Effect of school children:

Sleep and concentration disruption also relates to the performance of school children. Children from a school in Zone A were compared with children from a school which was unexposed, in terms of rate of promotion from primary to secondary school. They found a significantly slower promotion rate in the exposed school. They conclude that even though the association is weakened by a small sample size, an adverse effect from the transmitter "<u>cannot be ruled out</u>".

The children in Zone A are in the range of exposures (0.031-9.06μW/cm^2) which Von Klitzing (1995) shows that significant changes in human EEG occur in 70 % of subjects (0.7μW/cm^2). Reduced nocturnal melatonin and sleep disturbance would also be contributory factors. Hence a slowing of promotion was found and scientifically identified mechanisms also exist to reinforce this observations link to EMR. Learning difficulties associated with RF/MW exposure was also found by Latvian researchers, Kolodynski and Kolodynski (1996), and Chinese researchers, Chiang et al. (1989).

12.4 Chinese Study:

Chiang et al. (1989) studied subjects living and working near radio antennae and radar installations. Most of the studied exposures were above 10μW/cm^2, and they included microwaves and AM EMF. The tests carried out included visual reaction time, standardized written tests and white blood cell (WBC) phagocytosis. Visual reaction time increased significantly for Male Soldiers exposed to microwaves in the range 10-15μW/cm^2 ($p<0.01$) and Male College students exposed to 13-42μW/cm^2 of microwaves ($p>0.05$). Memory Function scores were also significantly reduced for both of these high exposed groups, $p<0.01$ for both groups. Secondary school boys and girls showed non-significant changes in visual reaction time (0-4μW/cm^2) but a significant improvement in memory Function Scores ($p<0.05$ for boys and $p<0.01$ for girls).

Blood tests associated with microwave exposure showed significantly elevated white blood cell counts for high school students ($p<0.05$) for exposure 0-4μW/cm^2. Male Soldiers in the middle range showed no effect and Male College Students in the high range showed a significant reduction in WBC.

AM exposure was associated with a 15 % increase in WBC in kindergarten children exposed to 3-4 V/m (2.4 - 4.2μW/cm^2) and a significant ($p<0.05$) 31.2 % increase at 4-11 V/m (4.2-32 μW/cm^2). Non significant reductions in WBC were found in 3rd year high school students at moderate exposures 10-18 V/m, but WBC were significantly reduced to 45.7 % for boys ($p<0.01$) and to 81.2 % for girls ($p<0.05$) in the range 22-23 V/m (128-140μW/cm^2).

The authors conclude "The data indicate that chronic exposures to EMFs are associated with significant changes in some physiological parameters."

Increased WBC at low exposures have been observed for example in the staff of the U.S. embassy in Moscow, exposed to mean exposures of somewhat less than 1/5th of the outdoor, upper floor measure mean exposures of 1 to 2.4μW/cm^2, i.e. less than 0.2 to 0.5μW/cm^2, produced a total WBC 25 % higher than average, with a 41 % increase in lymphocytes and 31 % increase in monocytes, Lilienfeld et al. (1978).

12.5 Summary of New Epidemiological Evidence:

These studied together show statistically significant increased in many important health and well-being factors in human beings exposed to a range of frequencies and intensities of residential expose and school exposure at levels well below 2μW/cm^2, being less than 0.01 to 0.2μW/cm^2 in the North Sydney cancer study; 0.0034μW/cm^2 (the bottom on Zone

B) in the Schwarzenburg Study (though Zone C also shows sleep disturbance effects); in Latvia at similar exposure levels, school children's performance is impaired and pine trees show decreased growth rates in mean measured exposure of 0.0027$\mu W/cm^2$ at 4 km from the radar, in the Skrunda Study.

13. Re-evaluation of Previous Evidence:

13.1 Introduction and background:

Four primary studies which were considered by the Planning Tribunal, are considered here. They are the U.S. Physiotherapists Study, the U.S. Navy Korean War Study, the Polish Military Study and the Von Klitzing Human EEG Study.

The Physiotherapist study has been re-evaluated in the light of strong evidence that the biological mechanism involves non-thermal processes and hence the use of a monthly averaging process for exposure regime is appropriate, and interpretation of the pattern of physiotherapist studies.

The re-evaluation of the U.S. Navy Korean War Study shows that using the data in the original paper, statistically significant adverse health effects were identified but not reported.

The Polish Military Study reported significant health effects from chronic RF/MW exposure but did not have exposure estimated associated with it. Analysis of the exposure regime described allows an annual mean career range of exposure to be estimated with a degree of reliability because of the hygiene regime which was in place and measurements which were made. Another 5 years of data has now been added and reported.

The human EEG study of Dr Lebrecht von Klitzing is reconsidered in the light of the author's (Neil Cherry) experience at having the procedure carried out on himself, re-evaluation of the exposure conditions and the consideration of animal EEG experiments.

13.2 U.S. Physiotherapists and Spontaneous Miscarriage:

13.2.1 The Study:

Ouellet-Hellstrom and Stewart (1993) carried out the largest study of physiotherapists in relation to early (first trimester) spontaneous miscarriage associated with expose to shortwave and microwave leakage fields from diathermy equipment. In a sample of 11,598 pregnant physiotherapists in the U.S., 6684 reported having ever used microwave or shortwave diathermy, 1791 of whom had experienced early spontaneous miscarriage. From these a case group (miscarriage) was selected for a microwave exposed group and a shortwave exposed group. Each person in these groups was matched with a control (pregnancy) person from the "ever exposed" group of 6684, making up a nested case-control study. These groups were then compared relative to their exposures in the six months prior to the pregnancy and in the first trimester.

Table 8: Unconditional odds ratios for the association between risk of recognised miscarriage and reported exposure to microwave diathermy during the 6 months prior to and the first trimester of pregnancy: Physical Therapists Study, 1989-1990.

	No. of exposures	Case pregnancies	Control pregnancies	OR*(95% CI)	κ^2 test for trend
All pregnancies	0	1,459	1,494	1.00	
	<5	88	86	1.05 (0.77-1.43)	
	5-20	72	49	1.50 (1.04-2.17)	
	>20	45	29	1.59 (0.99-2.55)	p>0.005
	Total no.	209	167	1.28 (1.02-1.59)	
No prior fetal loss	0	1,102	1,258	1.00	
	<5	71	76	1.07 (0.78-1.49)	
	5-20	58	47	1.41 (0.95-2.09)	
	>20	34	25	1.55 (0.92-2.61)	p>0.01
	Total no.	167	151	1.26 (1.00-1.59)	

An excess of miscarriages was found for microwave exposure (OR=1.28; CI: 1.02-1.59), with a statistically significant dose-response relationship (p<0.005), but no excess was found for shortwave exposure. In addition, of those miscarriages occurring in association which microwaves, 47.7 % occurred before the 7th week of gestation, whereas only 14.5 % of the unexposed miscarriages occurred in that period. Hence microwave exposure is highly related to accelerated early miscarriage but shortwave exposure isn't. Other studies, Kallen et al. (1982) for example, found shortwave exposure was associated with perinatal death and congenital deformity.

13.2.2 Types of Biological Mechanisms:

Two possible types of biological mechanisms have been proposed to explain this associated effect of microwaves and early spontaneous miscarriage. The first, favoured by the National Radiation Laboratory (NZ) and the Australian Radiation Laboratory staff, is a thermal mechanism, such as the production of heat lesions in the placenta and/or foetus, causing damage and subsequent miscarriage. This requires a significant temperature rise in the affected tissue. The second involves cumulative mutational DNA and aberrated chromosomes, probably involving enhanced free radicals. This mechanism is suggested by observations of aberrated chromosomes in blood analysis of people exposed to microwaves from radar, Garaj-Vrhovac and Fucic (1993).

13.2.3 The Heating Issue:

The key to resolving this is the ability of the known exposure regime to produce significant foetal heating or not. The highest exposure at 15 cm from the pads is 15 the top of the usual range is 1,200 $\mu W/cm^2$. Hocking and Joyner (1995) in their criticism of the paper, suggest that the result is implausible because shortwaves penetrate the foetus much more easily than do microwaves. Hocking and Joyner use a model developed by Telecom Australia to show that for a frontal exposure of 1000 $\mu W/cm^2$, the maximum SAR in the uterus is 0.209 W/kg for 27.12 MHz, 0.023 W/kg for 915 MHz and 0.000027 W/kg for 2,450 MHz. For the maximum conceivable exposure (15 mW/cm^2), the 915 MHz and 2,450 MHz SARs would be 0.345 W/kg and 0.00041 W/kg , respectively.

Ouellet-Hellstrom and Stewart (1995) in reply to Hocking and Joyner's comments state:

> **"We disagree with the general scientific view of Hocking and Joyner as expressed in their closing statement. In general, one should examine the extent to which competing explanations are supported by the data, not whether the data is supported by the explanations. The data are fixed, but the explanations are not."**

For normal blood flow the temperature rise rate at 4 W/kg is about 0.02 °C/min at 20 °C and 50 % RH, Adair (1993). This gives a 1 °C rise after 50 minutes. At 0.345 W/kg the heating rate will be about 0.0017°C/min. Hence a 2 to 5 minute exposure at the maximum conceivable rate would result in a foetal temperature rise of 0.004 to 0.009°C. This is far too low to cause thermal lesions and therefore rules this out as a possible mechanism.

13.2.4 Biologically Plausible Mechanism:

Electromagnetically reduced melatonin could be related to spontaneous abortion. According to Sandyk et al.(1992):

> **"The causes of spontaneous abortion can be divided into two main categories: those arising from chromosomal anomalies and those arising from abnormalities in the intrauterine environment. In the following communication, we propose that deficient pineal melatonin functions in early pregnancy may be causally related to the development of spontaneous abortions in cases where chromosomal anomalies or structural abnormalities of the uterus have been excluded."**

Microwaves are shown to be associated with DNA breakage in rats brains, Lai And Singh (1995, 1996) and to cause chromosome aberrations in living humans blood, Garaj-Vrhovac and Fucic (1993), and hence can produce the first cause of spontaneous abortion. Reduced melatonin allows greater concentrations of free radicals to exist. These damage the DNA and chromosomes, leading to a similar mechanism for miscarriage of the deformed foetus.

<u>Therefore, thermal shock and cumulative buildup of thermal lesions is implausible and cumulative cell damage, including melatonin mediated free radical chromosome damage is a highly plausible mechanism.</u>

Thus, it is appropriate to estimate the risk of spontaneous miscarriage in terms of monthly mean exposure since the dose-response relationship is expressed in terms of treatments per month. A significant occupational exposure will only occur then, if many treatments are given and the operator stands very close to the equipment for prolonged periods. Assuming a conservatively long estimate of 2 minutes exposure per treatment, the dosage per treatment is 0.01 to 0.144 J/cm^2.

13.2.5 Microwave dose associated with the risk:

One treatment per month is in the range 0.004 to 0.056 $\mu W/cm^2$, mean 0.03 $\mu W/cm^2$; 10 per month 0.04 to 0.56 $\mu W/cm^2$, mean 0.3 $\mu W/cm^2$; and 20 treatments per month 0.08 to 1.11$\mu W/cm^2$, mean 0.6 $\mu W/cm^2$. The lowest limit is very difficult to estimate with reliability but the mean level of the middle band is 0.3 $\mu W/cm^2$. This suggests that a 20 to 50% increase in miscarriage occurred with a mean monthly microwave exposure of somewhat less than 0.5 $\mu W/cm^2$.

13.2.6 Relevance to cell sites:

The fact that this level of microwave exposure is found near cell sites and that there are currently no documented reports of increased incidence of miscarriage occurring near cell sites is not surprising nor a proof that the hypothesis advanced here is wrong. It simply results from the fact that nobody reports or records miscarriage. Several other factors exists. Miscarriage is not reported and no statistics are being collected. Each pregnant woman can only miscarriage once per child, with a several month wait until the next pregnancy. Each spontaneous miscarriage is isolated and does not form a pattern. Many causes are possible and very few, if any are investigated unless it becomes an individual pattern and then a medical cause is sought. Few pregnant people live near cell sites. However with the unrestricted siting policy advocated by the companies and accepted by almost all councils, this is changing significantly month by month.

Increased incidence of miscarriage is potentially occurring right now and until it is scientifically assessed, we will not be able to rule out the scientifically indicated probability. It remains a potential adverse effect under the definitions of the Resource Management Act 1991. The studies presented here give ample grounds for requiring the siting of cell sites far enough away from residences to avoid an increase in risk through sections 5 and 3 of the Act.

A statistically significant 50 % increase in miscarriage risk was identified with 5 to 20 treatments per month. Taking the typical number in this range as 10 treatments per month the mean exposure is in the range 0.04 to 0.56 $\mu W/cm^2$. A public exposure limit of 0.1 $\mu W/cm^2$ should be adopted until the effect was conclusively show to occur at or below this level, or not at all.

13.3 U.S. Navy Korean War Study:

Robinette et al. (1980) was quoted by Dr Michael Repacholi in evidence for BellSouth, following the conclusions stated in the original paper, as showing no effects from exposure to radio and RF/MW radiation. Doubt was thrown on these conclusions at the hearing by Professor of Epidemiology, Dr John Goldsmith on the basis of published original paper when she said in relation to the results of this study, Silverman (1979), "while some significant differences among the occupational groups classified by level of potential exposure have been found with respect to all end points studied, the differences could not be interpreted as a direct result of microwave exposure." Professor Goldsmith was clearly stating that Dr Silverman had concluded that significant differences has been found in all studied end points, and that this was at variance with the conclusions of the 1980 paper.

His Honour Judge Sheppard, in writing up his decision, incorrectly associated Dr Silverman's difference of conclusion with the study by Dr Szmigielski on Polish Military personnel which found significant increases in cancers, Szmigielski et al. (1988).

<u>This created a double error suggesting that both military studies had shown no effects, when the reality is that both do show significant adverse health effects.</u>

Robinette et al. (1980) acknowledge the strong possibility of misclassification of exposure hazard. They carried out a survey of the assumed high exposure groups and a hazard number was allocated to each. Electronics Technicians (ET) were 1620, Fire Control Technicians (FT) were 2870 and Aviation Electronics Technicians were 3700. Hence a low versus high exposure comparison can be made taking the incidence ratio (Risk Ratio) between ET and AT, Table 9.

This analysis is much more consistent with Dr Silverman's conclusions reported in the 1979 conference paper, Silverman (1979). It is also consistent with the substance of the material in the original paper. In that the original data shows a significant increase in mortality risk for the high exposure group, the stated conclusion in the abstract of the paper is <u>clearly wrong and misleading</u> when it states:

> **"No adverse effects were detected in these indices that could be attributed to potential microwave radiation exposures during the period 1950-54."**

The error of this statement is clear from the analysis presented in tables 9 and 10. It is even more clear with a consideration of the morbidity data derived from men receiving VA compensation for treatment, Table 12 from Robinette et al. (1980).

Robinette et al. (1980) stress that while considering the data about death, other disease would have been present which would not be reported:

> **"Further, it is possible that effects involving cardiovascular, endocrine and central nervous system do exist, but are transient, disappearing with the termination of exposure or soon thereafter, or are not perceived to be sufficiently consequential to result in admission to hospital."**

Morbidity effects were investigated using VA compensation claims. The average exposure of the FT+AT group is 3286. Table 10 is extracted from the data in Table 12 in Robinette et al. (1980).

Table 9: Mortality Incidence per 1000 and Risk Ratio (AT/ET) as an indication of the high exposure to low exposure difference.

Cause of Death	Incidence / 1000 Low Exposure ET	Incidence / 1000 High Exposure AT	Risk Ratio
All causes	3.37	6.05	1.80
Accidents	1.35	2.96	2.20
Suicide, Homicide, Trauma	0.44	0.61	1.39
All disease	1.52	2.35	1.55
Malignant Neoplasms	0.50	0.82	1.65
Digestive organs and perit.	0.11	0.12	1.11
Respiratory System	0.12	0.21	1.78
Skin	0.02	0.06	2.66
Brain, eye and nervous system	0.04	0.09	2.39+
Lymphatic and hematopoietic	0.14	0.31	2.21
Circulatory System	0.76	0.95	1.25
Digestive System	0.08	0.28	3.27
Other Diseases	0.16	0.28	1.71

+ refers to FT/ET

Table 10: Number of men receiving VA compensation and pension, December 1976 and rates per 1000 men by diagnosis and exposure class, and Risk Ratio (FT+AT)/ET.

	ET		FT+AT		Risk Ratio
Mean Hazard Index	1620		3286		
	No.	Rate	No.	Rate	
Diagnosis:					
Musculoskeletal	115	8.8	119	16.9	1.93
Organs of special sense	49	3.7	42	6.0	1.62
Systematic conditions	3	0.2	5	0.7	3.50
Respiratory	55	4.2	51	7.3	1.74
Cardiovascular	43	3.3	47	6.7	2.03
Digestive	74	5.7	55	7.8	1.37
Genitourinary	31	2.4	10	2.7	1.13
Skin	83	6.3	58	8.2	1.30
Endocrine	15	1.1	11	1.6	1.45
Neurological	21	1.6	16	2.3	1.44
Nerves	15	1.1	3	0.4	0.36
Mental Conditions	51	3.9	46	6.5	[illegible]

Table 9 shows that sickness was considerably higher amongst the highly exposed group compared with the low exposure (ET) group. The following have Risk Ratios elevated by 30 % or more: Musculoskeletal (RR = 1.93), Organs of special sense (RR = 1.62), Systematic conditions (RR = 3.5), Respiratory (RR = 1.74), Cardiovascular (RR = 2.03), Digestive (RR= 1.37), Skin (RR = 1.30), Endocrine (RR = 1.45), Neurological (RR = 1.44), and Mental Conditions (RR = 1.67).

A part of the Respiratory disease and Cardiovascular Disease increase could be attributable to increased incidence of smoking. However these do not account for all of the increase in these diseases, nor of the wide range of disease increase detected.

Note also that the reference group, ET, have an elevated Hazard Number compared to other servicemen and considerably elevated compared to the general public. Hence the Risk Ratios are quite large underestimates of the effect of increased chronic exposure to microwaves emitted by radar.

Dr Ruey Lin of the Maryland Department of Health, Lin (1985) reviewed this study and concluded that the exposed and control groups were in fact both exposed groups, leading to an under-estimate of the identified effects.

Since all of the subjects are acknowledged to have some radar exposure on a regular basis, such as when they are on deck, it is relevant to compare the incidence of mortality of the servicemen with a large group of unexposed men. Cancer mortality statistics are available for New Zealand men. Since rates of cancer death rise with age a well define age cohort is necessary.

As of 1952, 88.7% of the studied service men were 25 or younger. Mortality analysis covered the period to 1974 making around 89% being 47 years old or less. The standardized mortality for death from cancer for all causes of cancer in Males in New Zealand in the 25 to 49 age group is 2.21 per 1000. All of the Korean War veterans have a far higher rate than this and all would have been exposed to more radar signals than the New Zealand population. The highly exposed AT group has a rate which is 3.27 times higher than the New Zealand male rate.

Even the lowest rate for Radiomen at 4.21/1000 is 1.9 times higher than the New Zealand age adjusted male all cancer rate. The highest rate for Aviation Electronics Technicians (8.25/1000) is 3.73 times higher.

13.4 Polish Military Study:

13.4.1 Background:

Szmigielski et al. (1988) carried out an extensive retrospective study of Polish Military personnel with radar exposure, covering a longer period to allow for the latency of cancers. This was updated to extend the period involving cancer morbidy to between 1971 and 1985, Szmigielski (1996). The mean annual population was 128,000 with around 3700 (3%) being considered to occupationally exposed to RF/MW. In this group statistically significant increases in many forms of cancer were detected, consistent with the Moscow study below. No analysis of the exposure regime was presented to the Planning Tribunal. While it was impossible to assign an exposure to each individual, the exposure regime was extensively studied and it is possible to make an estimate of the likely career mean range of exposure for those with very high exposures, setting the likely maximum exposure range for the effects identified.

13.4.2 Exposure Assessment:

Szmigielski (1996) states that the exposure regime was considerably more uniform than most exposures because of exposure hygiene controls and reporting of high exposures. Szmigielski (1988) describes the daily exposures as 4-8 hours below 200μW/cm^2 with several minutes in the range 200-1000μW/cm^2. Incidents of short-lasting exposures estimated up to 10-20 mW/cm^2 were reported but were more frequent before 1960 when the hygiene controls were introduced.

Exposures were extensively measured by military safety groups, with the finding that 80%-85% of the posts were in the 10-200μW/cm^2 range, and 15 % in the 200-600μW/cm^2 range, and where EM fields mostly pulse-modulated RF/MWs at 150 to 3500 MHz. Safety rules limiting exposure were established in 1961 and are outlined in Table 11.

Table 11: Polish Occupational exposure standards (Czerski (1985)) for RF/MW exposure, 300 MHz - 300 GHz. Exposure in μW/cm^2

Zone	Stationary Antennae	Rotating antennae
1) Safe, Human occupancy unrestricted	< 10	< 100
2) Intermediate, access limited to authorized personnel, occupational exposure permissible during work shift.	10 - 200	100 - 1000
3) Hazardous, access limited to authorized personnel, duration of exposure (t in hrs) defined by the formula in parentheses. (p in W/m^2: 1 W/m^2 = 100μW/cm^2)	200 - 10,000 ($t=32/p^2$)	1,000 - 10,000 ($t=800/p^2$)
4) Danger Zone, human occupancy prohibited.	> 10,000	> 10,000

A highly exposed person would spend most of the day away from the minimal exposed (safe-zone) environment, at home or any other away from work activity. Most of the working day is likely to be spent in a safe zone < 10 μW/cm^2. A moderate amount of time in the intermediate zone (10-200 μW/cm^2) and a few minutes in the hazard zone (200-1000 μW/cm^2). A person in a highly exposed occupation was generally required to follow hygiene principles set out in the Standard. Hence the maximum exposure regime is suggested in Table 12:

Table 12: Maximum daily exposure scenario for a very highly exposed serviceman.

Zone classification and safety limits	Daily Time	%
Hazard Zone (200-1000 $\mu W/cm^2$, average 153 $\mu W/cm^2$)	6 minutes	7.5
Intermediate Zone (10-200 $\mu W/cm^2$, average 30.6 $\mu W/cm^2$)	6 hours	89.9
Safety Zone (<10 $\mu W/cm^2$, average 1.5 $\mu W/cm^2$)	1.9 hours	1.4
Residential (<1 $\mu W/cm^2$, average 0.153 $\mu W/cm^2$)	16 hours	1.2

Because the exposure distribution is skewed, the mean and median exposures are closer to the lower bound of the range. From Tell and Mantiply (1980), the distribution of population exposures in major US cities, the mean is $0.01\mu W/cm^2$, median is $0.005\mu W/cm^2$ and the 15 percentile is $0.069\mu W/cm^2$. Hence the ratio of the upper 15 percentile to the mean is 0.153. Applying this factor to the upper limit of each exposure class gives an approximate estimate of the mean exposure.

The regime in Table 12 gives a workday mean of $8.5\mu W/cm^2$, and a working week average of 6.0 $\mu W/cm^2$, and an annual average (assuming 46 working weeks) of 5.4 $\mu W/cm^2$. Note that 5.4 $\mu W/cm^2$ is 540 times higher than the mean U.S. urban exposure of 0.01 $\mu W/cm^2$. The residential exposure in Table 12 ($0.153\mu W/cm^2$) is over 15 times higher than the U.S. urban mean. This is appropriate because most servicemen live on or near the military base and hence are exposed to radar signals. Lester and Moore (1982, 1985) found increased cancer rates in cities adjacent to air force bases. Radar and radio servicemen are in the intermediate zone for 4 - 8 hours, and It is unlikely that a serviceman would be in this highly exposed regime for all of their career and so long-term mean maximum exposures are likely to be less than this, say 40-80 %. Using the extremes of each of these gives the range 1.6-5.6 $\mu W/cm^2$ for the career maximum average exposure for Polish servicemen.

13.4.3 Summary of Health effects:

Prof. Szmigielski has published the health effects data in two parts, Szmigielski (1988) and Szmigielski (1996), the first covering the period 1971 to 1980 and the second 1971-1985. Szmigielski (1988) reached the following conclusions:

> **"In summary, from a retrospective study that covered a large, well controlled population with a known population of subjects, and that has a relatively long period of observation (1971-1980) the following conclusions can be drawn:**

- **The risk of developing clinically detectable neoplastic disease was about 3 times higher for the personnel exposed occupationally to MW/RF radiation. The higher risk appeared for malignancies originating from hemato-lymphatic systems (morbidity about 7 times higher). Other more frequent neoplasms were located in the alimentary tract and in skin (including melanomas).**

- **The highest risk factor of cancer morbidity related to occupational exposure to MW/RFs appeared for subjects at the age of 40-49 who had a 5-15 year period of exposure.**

- **Morbidity rates of neoplasms in personnel exposed occupationally to MW/RFs showed a strong correlation with the period of exposure.**

- **Neoplasms (cancer tumors) of the same localization and/or type developed earlier (by about 10 years) in personnel exposed occupationally to MW/RFs than in those not working in the MW/RF environment.**

The extension to 15 years of data was reported in Szmigielski (1996). The results are in Tables 13, 14 and 15.

Hence the Polish Military study gives conclusive and strong associations of RF/MW exposure and increases in a host of cancers and a large increase in cancer death. Table 14 shows the incidence ratios (Odds Ratio: OR) for the ratio of exposed to non-exposed personnel, after Szmigielski (1996).

Table 13: Incidence of haemopoietic and lymphatic malignancies (per 100,000 subjects annually) in military personnel exposed and non-exposed (control) to radiofrequency and microwave radiation.

Type of malignancy	Incidence Non-exposed	Incidence Exposed	RR	95 % Confid.	Significance
Hodgkin's disease	1.73	5.12	2.96	1.32 - 4.37	<0.05
Lymphoma (non-Hodgkin and lymphosarcoma	1.82	10.65	5.82	2.11 - 9.74	<0.001
Chronic lymphacytic leukaemia	1.37	5.04	3.68	1.45 - 5.18	<0.01
Acute lymphoblastic leukaemia	0.32	1.84	5.75	1.22 - 18.16	<0.05
Chronic myelocytic leukaemia	0.88	12.23	13.90	6.72 - 22.12	<0.001
Acute myeloblastic leukaemia	0.71	6.12	8.62	3.54 - 13.67	<0.001
Total	6.83	43.12	6.31	3.12 - 14.32	<0.001

The analysis here identifies the likely highly exposed regime as being between 1.6 and 5.6 μW/cm^2. Professor Szmigielski forms the following conclusions concerning cancer risk from this study, Szmigielski (1996):

> ***"The main results obtained in the present study were a doubled incidence of all neoplasms, with a three fold increase of cancers of the alimentary tract and a six-fold increase of malignancies of the haemopietic system and lymphatic organs in 20-59 year old career military servicemen exposed to pulse modulated 150 - 3500 MHz RF/MW radiation."***

Table 14: Incidence of neoplasms (tumors) (per 100,000 subjects annually) in age groups of military personnel exposed and non-exposed (control) to radiofrequency and microwave radiation, Szmigielski (1996).

All sites:

Age Group	Incidence Non-exposed	Incidence Exposed	OR	95 % Confidence limits	Significance (p-value)
20-29	11.62	21.11	2.33	1.23 - 3.12	<0.05
30-39	18.37	42.28	2.30	1.04 - 3.06	<0.05
40-49	84.29	161.62	1.92	0.98 - 2.84	<0.05
50-59	186.71	274.13	1.47	0.92 - 2.21	N.S.
All Ages	57.6	119.12	2.07	1.12 - 3.58	<0.05
Haemopoietic/lymphatic malignancies					
20-29	2.12	17.30	8.16	3.11 - 22.64	<0.01
30-39	3.08	26.43	8.58	3.46 - 19.58	<0.01
40-49	8.32	73.25	8.80	4.13 - 15.27	<0.01
50-59	24.13	108.62	4.47	2.56 - 6.81	<0.01
All ages	6.83	43.12	6.31	3.12 - 14.13	<0.001

Table 15: Incidence of neoplasms (per 100,000 subjects annually) in military personnel exposed and non-exposed (control) to radiofrequency and microwave radiation, Szmigielski (1996).

Localization of malignancies	Incidence (Expected)	Incidence (Exposed)	Risk Ratio	95% CI limits	p-value
Pharynx	1.96	2.12	1.08	0.82-1.24	N.S.
Esophageal and stomach	4.83	15.64	3.24	1.85-5.06	<0.01
Colorectal	3.96	12.65	3.19	1.54-6.18	<0.01
Liver, pancreas	2.43	3.58	1.47	0.76-3.02	N.S.
Laryngeal, lung	21.89	23.26	1.06	0.72-1.56	N.S.
Skin, including melanomas	3.28	5.46	1.67	0.92-4.13	<0.05
Nervous system including brain tumour	2.28	4.36	1.91	1.08-3.47	<0.05
Thyroid	1.38	2.12	1.54	0.62-2.59	N.S.
Haematopoietic system and lymphatic organs	6.83	43.12	6.31	3.12-14.32	<0.001
All malignancies	57.60	119.12	2.07	1.12-3.58	<0.05

13.4.4 Conclusions:

Dr Szmigielski states that this does not prove a causal link but the high incidence of certain forms of neoplasms in personnel exposed to pulse-modulated RF/MW radiation clearly shows a need for urgent identification of causal factors present in the occupational environment. However, in the context of the studies presented in this review, there are plausible mechanisms to relate the observed increases in cancer to altered cellular behaviour, these results are consistent with animal experiments, and with many other epidemiological studies.

The task now is to place the evidence in a more objective assessment context. A classification scheme has been assembled to assist with this.

13.5 Brief Overview of Epidemiology and RF/MW association with cancer:

The studies reviewed above in detail are important in the context of the evidence before the Environment Court in New Zealand. It should be noted that there are many other studies which have found statistically significant increases in adverse health effects, including cancer. It is not that there is no evidence, nor even limited evidence of adverse effects. The truth is their is a large body of evidence, only part of which is reviewed here.

The following give a brief summary of some of the published studies showing adverse effects from RF/MW effects on people.

- More neurasthenic symptoms in group exposed to radar (Djordevic et al., 1979);
- Higher frequency of polycythemaemia with microwave exposure (Friedman, 1981);
- Duration and severity of tonsillitis increased with combined air pollution and RF exposure (Shandala and Zvinjatskovsky, 1988);
- Association between heart disease and work with shortwave therapies, increasing with the number of treatments/week (Physiotherapists using 27 MHz diathermy) (Hamburger et al., 1983);
- Upper limb paraesthesia and eye irritation among 30 exposed workers using 27 MHz plastic sealers (Bini et al., 1986);
- Increased risk of cancer morbidity in radar exposed Polish military personnel (Szmigielski et al., 1988);
- Increased rates of paraesthesia in hands, neurasthenia and eye complaints, using 27 MHz plastic welders and sewing machines (Kolmodin-Hedman et al., 1988).
- Increased protein band in CSF in exposed group or radar mechanics (Nilsson et al., 1989)

- Lester and Moore (1982) found significantly higher cancer rates in U.S. counties with Air Force bases compared to those without Air Force bases, which they related to prolonged environmental exposure to RF/MW from radar.

- Lin et al. (1985) studied 951 cases of brain tumors among white male residents of Maryland during the period 1969-1982. Fifty cases of glioma and astrocytoma were observed among electrical workers exposed to EMR compared to an expected number of 18, i.e. an risk ratio of 2.8. While their exposure was mainly to ELF fields it shows the common link over a wide range of frequencies.

- Thomas et al. (1987) report a 10-fold increase in astrocytic brain tumor among electronics and repair workers employed for 20 years or more. Some risk was due to solvents, put at a factor of 2, placing RF/MW contribution at a factor of 5.

- De Guire et al. (1987) report increased malignant melanoma of the skin in workers in a telecommunication industry, affecting only men, SIR = 2.7 CI : 1.31-5.02).

- Increased risk of leukaemia amongst amateur radio operators (Milham, 1985).

- Milham (1988) studied 67,829 amateur radio operators in Washington State and California. He concludes "The all-cause standardized mortality ratio (SMR) was 71 but a statistically significant increased mortality was seen for cancers of the other lymphatic tissues (SMR = 162), a rubric which includes multiple myeloma and non-Hodgkin's lymphomas. The all leukemia SMR was slightly but not significantly elevated (SMR = 124). However, mortality due to acute myeloid leukemia was significantly elevated (SMR = 176).

- A doubling of miscarriage rates has been reported in women working at computer terminals for more than 20 hours/week in the first three months of pregnancy (Goldhaber et al. 1988). Note that VDU's emit a wide range of RF radiation.

- Szmigielski et al. (1988) studied polish military personnel exposed to microwave radiation and reported that cancer morbidity was three times higher in the exposed group than the control group.

- Electrical workers in Los Angeles county have a 4.3-fold increased risk of certain brain tumors (Preston-Martin et al. 1989).

- An increased incidence of malignant brain tumors has been reported in children of fathers exposed to electromagnetic fields and electronic solvents (Johnson and Spitz, 1989).

- Hayes et al.(1990) report an Odds ratio for all testicular cancer of 3.1 (CI: 1.4-6.9) for a small sample of workers who were occupationally exposed to RF/MW radiation.

- W Shao-Guang, et al. (1990) reports a Chinese study which found a significant increase in neurasthenic syndrome backed up by blood biochemical changes.